BACKGROUND INFORMATION:

Space Transportation System (STS)-133/External Tank (ET)-137 Intertank (IT) Foam Crack and Stringer Repair Assessment

Lesson Learned Submission

Resources:

Gentz, Steven J., Space Transportation System (STS)-133 External Tank (ET)-137 Intertank (IT) Foam Crack and Repair Assessment, NASA/TM-2012-217338 and NESC-RP-10-00680, NASA Langley Research Center, Hampton, VA, February 2012

Report No. LMC-ET-SE61-1, Space Shuttle External Tank System Definition Handbook SLWT, Configuration and Operation, Vol. 1, Lockheed Martin Michoud Space Systems, New Orleans, Louisiana, December 1997

Lengyel, David, SLWT Risk Management Case Study, NASA Exploration Systems Directorate, Integrated Risk & Knowledge Management Program, July 2009

NASA –Space Vehicle Structure, External Tank, http://science.ksc.nasa.gov/shuttle/technology/sts-newsref/et.html#et-intertank, accessed 2012-05-09

NASA Fact Sheet: ET, http://www.nasa.gov/returntoflight/system/system_ET.html, accessed 9 May 2012

Background Information about the Intertank:

The Intertank (IT) of the External Tank (ET) "is a steel/aluminum semimonocoque cylindrical structure with flanges on each end for joining" the two liquid propellant tanks. The IT houses the SRB cross beam, an umbilical plate for interfaces with the ground facility, and instrumentation components. IT stringers are hat-section Al-Li beams that span the distance between the forward and aft rings of the IT (270 inches) to reinforce the skin panels. Most of the 18 external stringers are roll-formed and selectively chem-milled, although some are machined from extrusions. They are equally spaced around each panel, providing buckling and flutter resistance, distributing loads to the attachment flanges, and providing for the attachment of mounting brackets for subsystem lines and cable trays. They are mechanically fastened to the skin panels and flanges.

The SRB crossbeam carries the majority of the Orbiter and ET weight to the SRBs and is the primary load train for vehicle loads. The stringers do not contribute structural support to the vehicle load train involving the crossbeam. Two thrust panels (not skin panels), thrust panel longerons, and doubler plates provide added stability for the compressive loading of the forward section where it attaches to the SRBs. Skin reinforcing doublers are located adjacent to the thrust panels and LOX tank attachment flange ring to distribute SRB thrust loads.

Structural modeling and analysis of stringer behavior under manufacturing, assembly, and operational loading conditions was virtually non-existent prior to the STS-133 observation, and was not greatly increased during the investigation due to the termination of the shuttle program two flights later. Mechanical behavior of Al-Li and sensitivity to manufacturing variability was not understood as well as that of the predecessor material, an aluminum-copper alloy because Al-Li was a material developed and refined specifically for the ET. Additionally, Al-Li can behave more like a composite than a homogenous metal.

Structural strength capability and material acceptance requirements were documented in the material specification. While meeting all specification requirements, the investigation discovered that a wavy surface appearance was common to stringers prone to crack initiation. The surface roughness and contour were within the specification requirements, although it was noted that the particular lot of stringers that appeared susceptible to cracking were thinner on average than other stringers in the inventory. Conducting root cause analysis regarding stringer material was complicated by the long duration between procurement of the material and actual flight of the assembled hardware, so no clear relationship was able to be established between the fracture properties and potential manufacturing deviations with the rolling process.

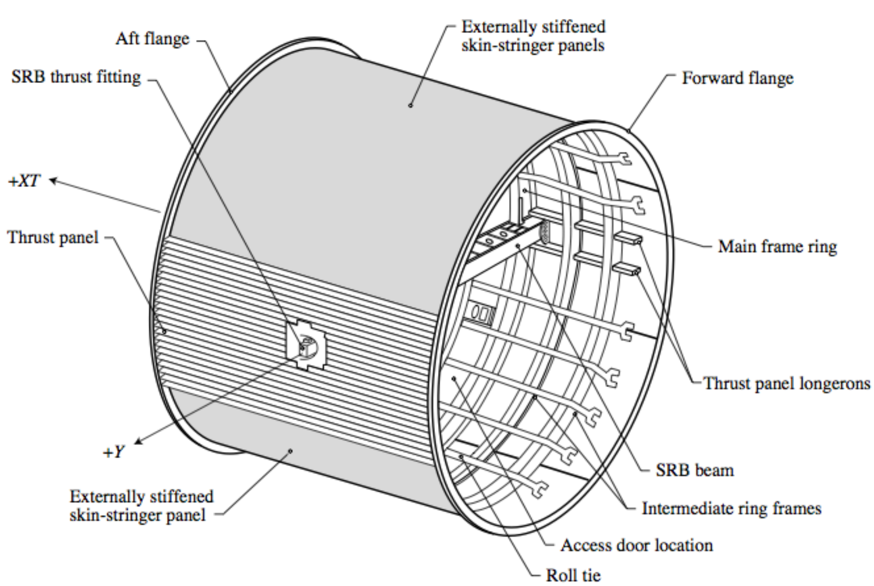

Figure 3. Intertank structure.

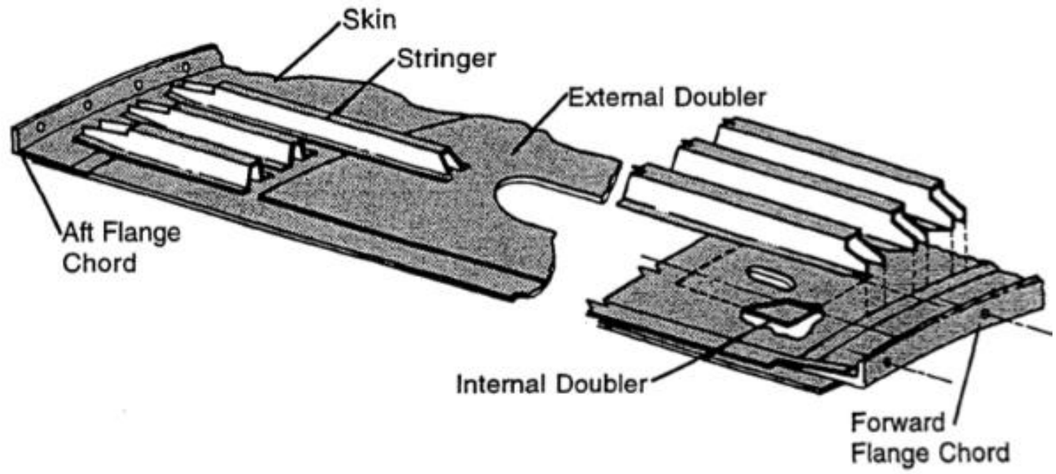

Figure 7-6: Panel Penetrations and Reinforcements